The Role of Renewable Distributed Generation in California's Electricity System

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Basic Definitions

- Distributed Generation
  - Electricity generation from small and dispersed systems located close to the demand sites and able to meet demand with minimal grid connection
  - Typically less than 20 MW (ideally smaller)
- Renewable Energy Resources
  - Energy sources that can be replenished by natural environmental cycles over short time periods
  - Typically energy from wind, biomass, geothermal, water and solar resources

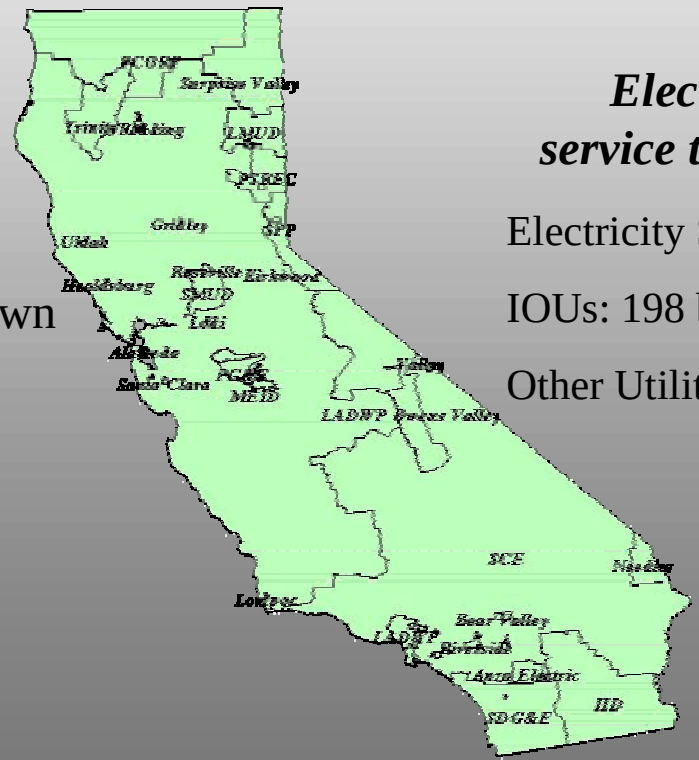
California's Electricity System

A Mix of Players ....

- IOUs, Municipal Utilities, Irrigation Districts, Electricity Service Providers, Rural Electric Cooperatives, etc.

Using a Blend of Regulated and Deregulated Components

- ***Generation***: Deregulated, but IOUs still own 20% of generation
- ***Transmission***: Quasi-deregulated
  - ✔Lines owned by IOUs
  - ✔Transactions controlled by ISO/FERC
- ***Distribution***: Regulated
  - ✔Lines owned by IOUs; services open
  - ✔Regulated by CPUC



Electricity service territories

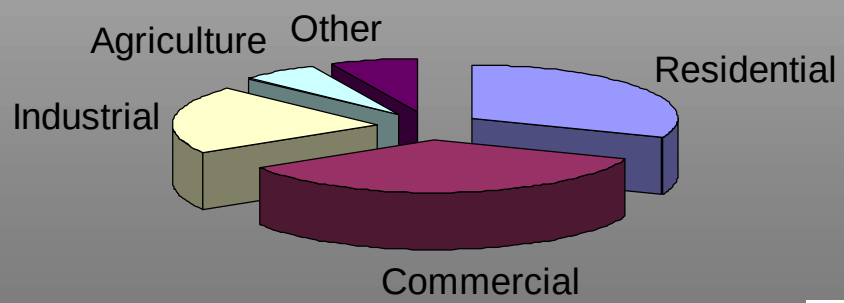
Electricity Sales (GWhrs)

IOUs: 198 billion

Other Utilities: 66 billion

California's Electricity Demand

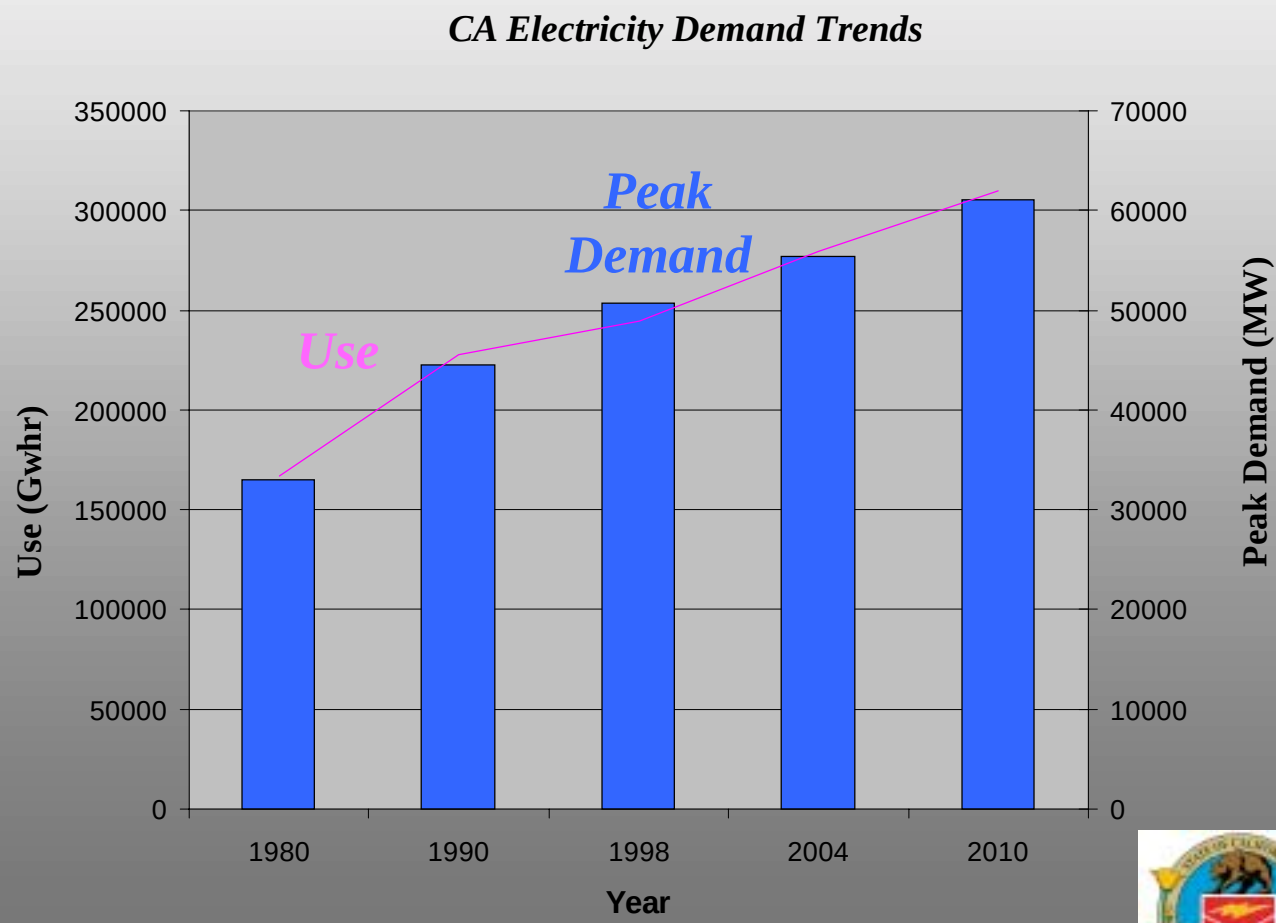
- 2nd largest electricity use in country
  - Service to over 13 million customers
  - Peak demand over 53 gigawatts and consumption over 264,000 Gigawatt-hours annually
- Four primary sectors account for over 90% of demand
  - Residential: 31%
  - Commercial: 35%
  - Industrial: 21%
  - Agriculture: 6%



Electricity Demand Trends

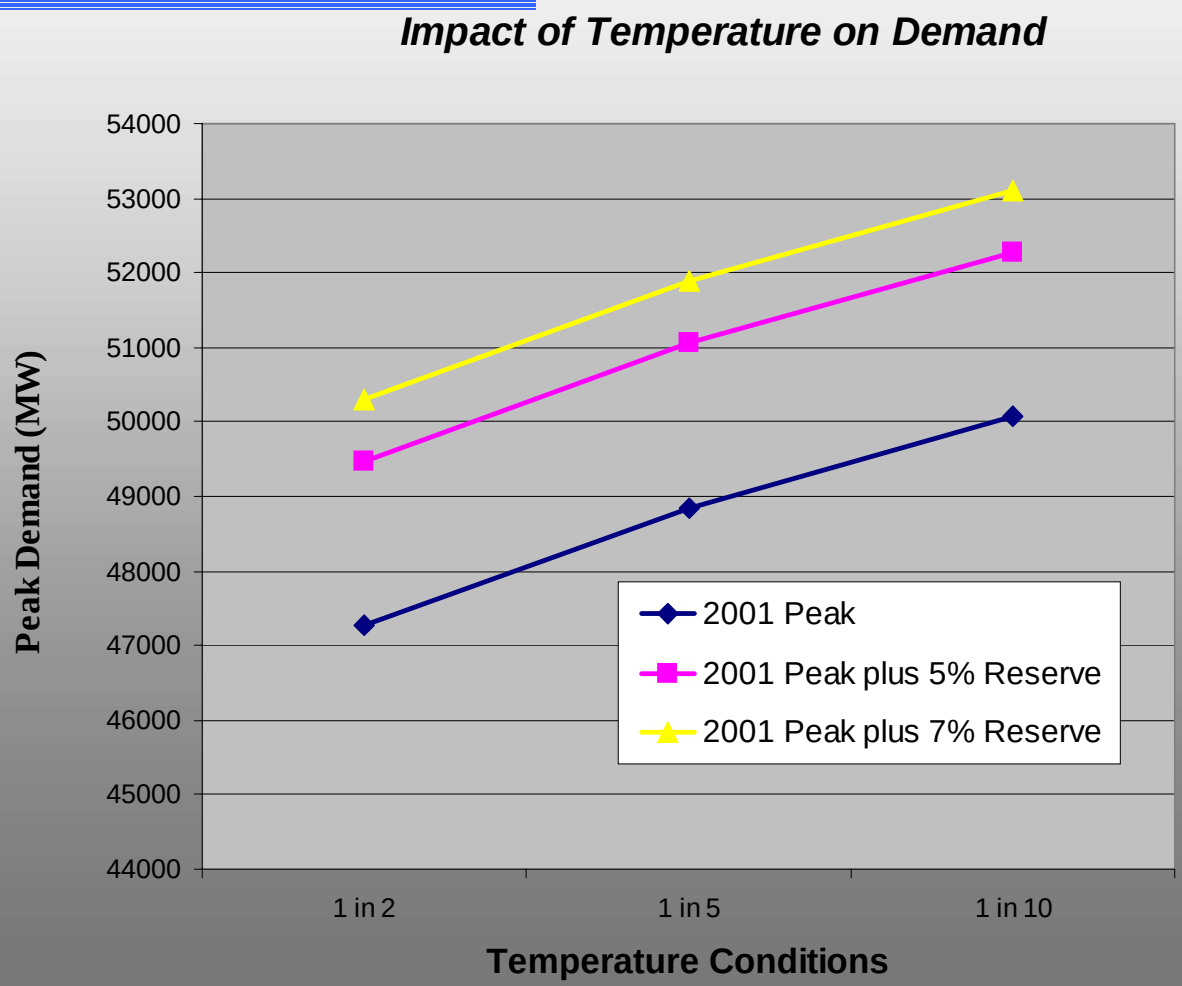
Future demand will be significantly affected by needs and locations of residential & commercial sectors

- Residential and commercial together make up 2/3rds of demand through 2010
- Residential demand tied to households and household demand
- AC and lighting account for over 50% of residential use
- Movement into hotter inland areas occurring



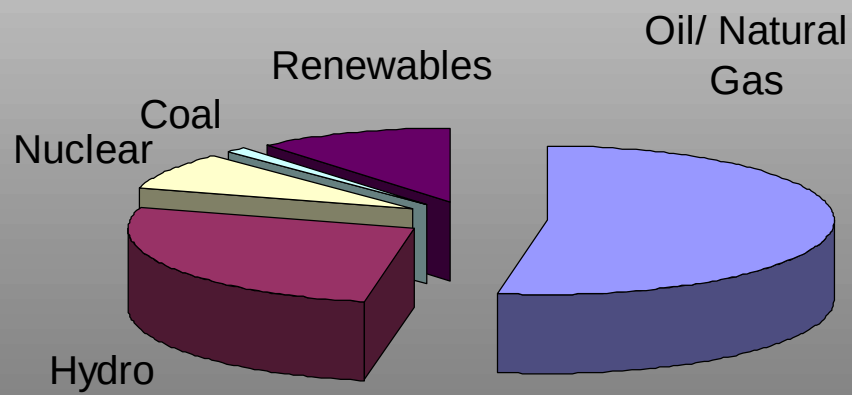
Impacts of Temperature on Demand

Warmer temperatures and increased population of residential and commercial sectors into hotter inland areas can have large impacts on peak demand



California's Electricity Supplies

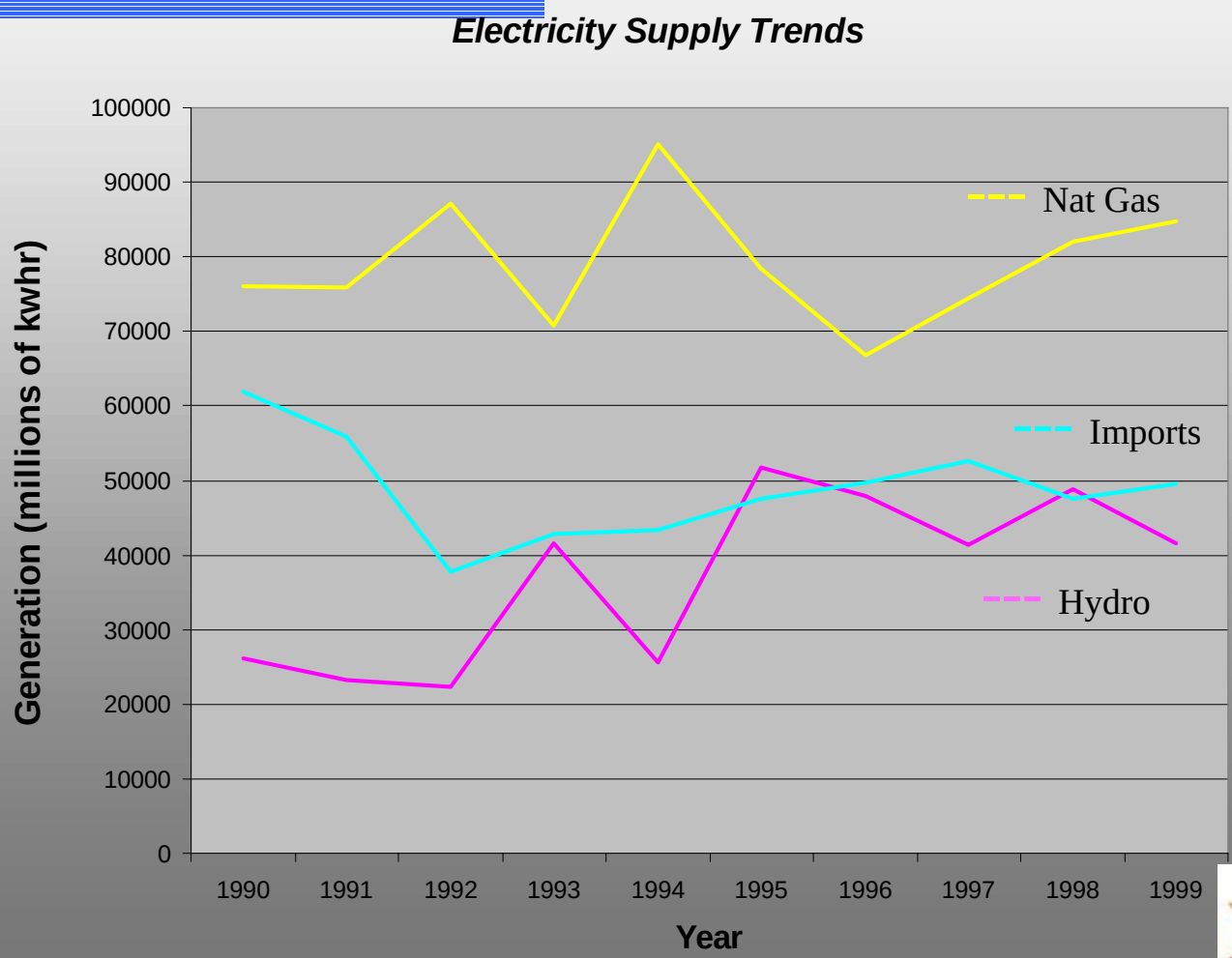
- Total generation over 275,000 Gwhrs/yr
  - Approx. 20% imported
- In-state capacity*
  - Oil/Natural gas: 53%
  - Hydroelectric: 27%
  - Nuclear: 8%
  - Coal: 1%
  - Renewables: 11%



* Total capacity at 53 GW

Electricity Supply Trends

Since 1990, California has become increasingly dependent on natural gas based generation and hydroelectric supplies



Issues Facing California's Grid At 2000

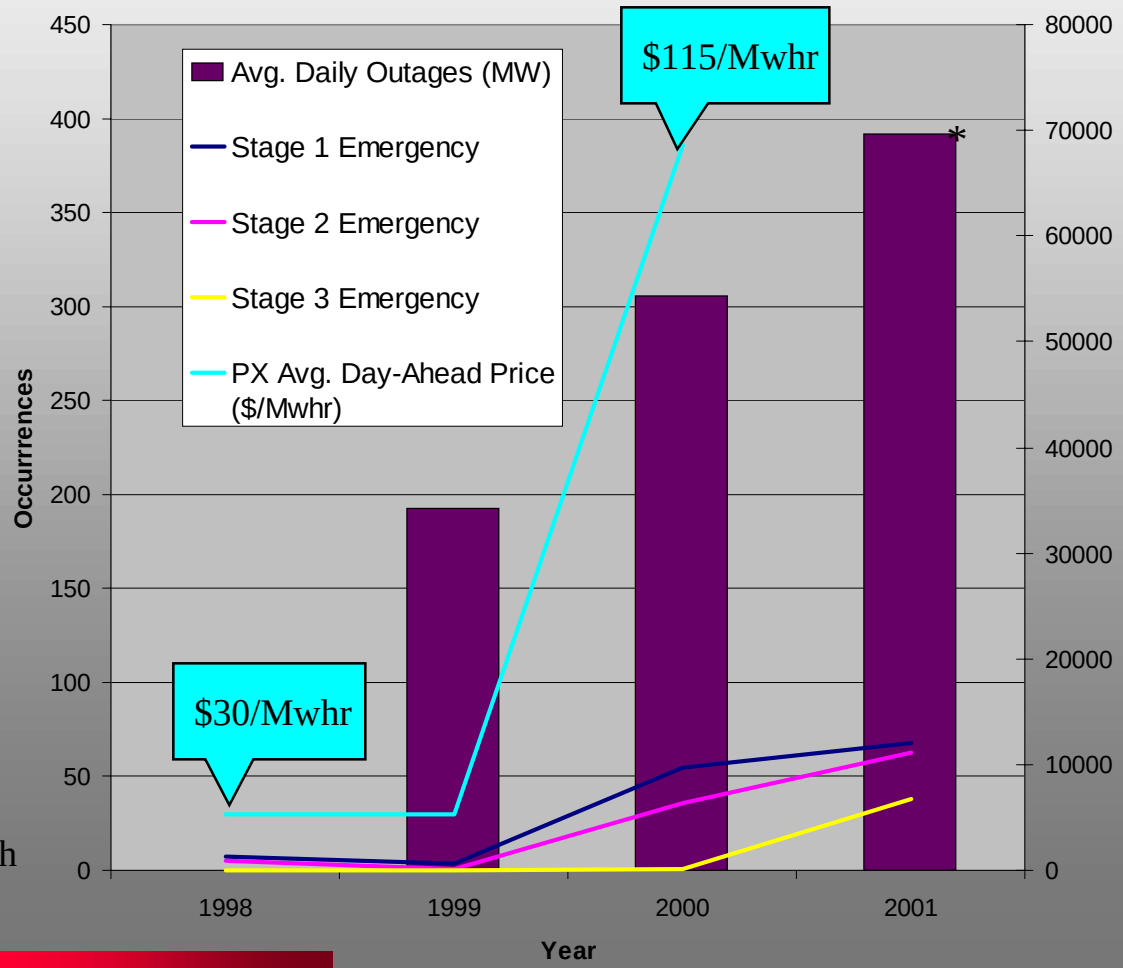
- **Capacity**
  - *Declining reserve capacities occurring across California; uneven demand growth in relation to infrastructure; constraints on new capacity construction and siting*
- **Reliability**
  - *Increasing outages and voltage dips causing increasing reliability problems; power flow anomalies creating local bottlenecks and quality problems*
- **Prices**
  - *Wholesale electricity prices increased significantly over 1999 levels; peak prices escalating even more rapidly*

What About T&D System?

- **Vulnerability to voltage drops or outages**
  - Long radial lines with loads far from generation
  - Load growth or changes in load shape straining substation capacities
- **Outlook on T&D**
  - Pending equipment upgrades or replacements caused by age
  - Underground service is expensive or disruptive to replace
  - Increasing congestion
  - Strong utility outlook that distribution lines are only for one way power flow

CA Electricity System Entering 2001

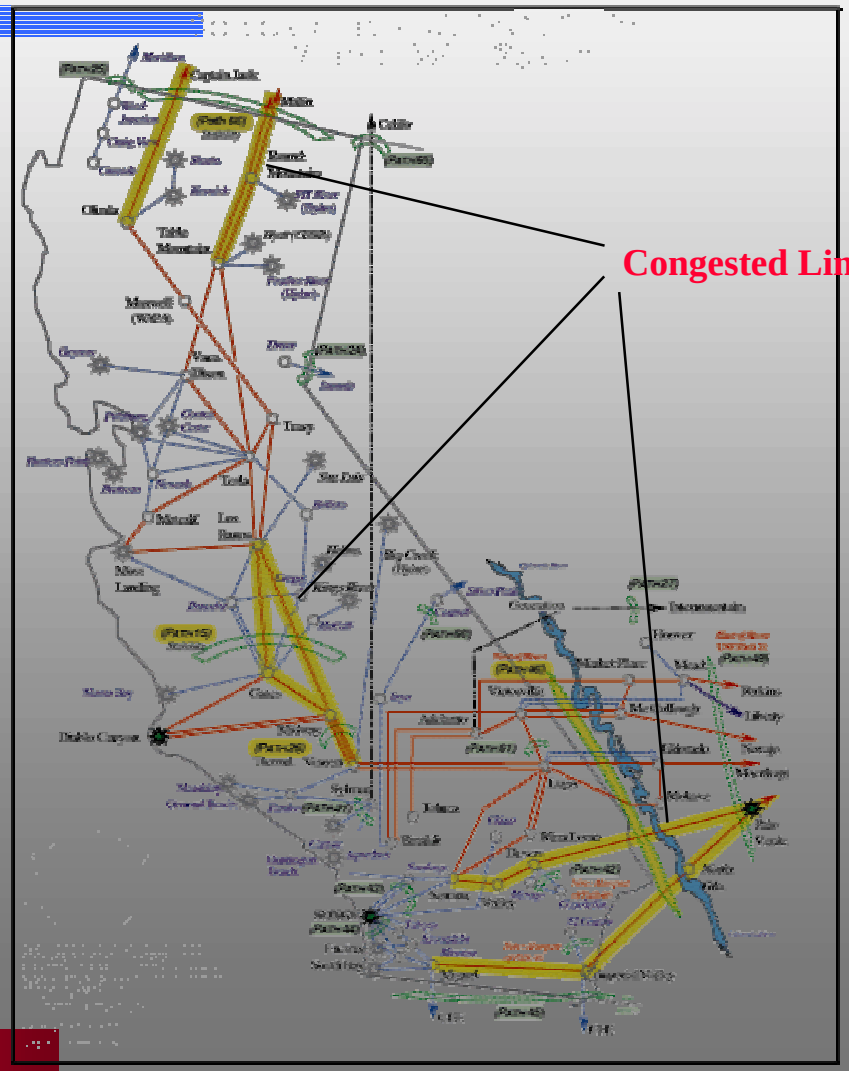
As capacity fell short of demand, CA saw a dramatic increase in staged alerts, high price volatility and rolling blackouts



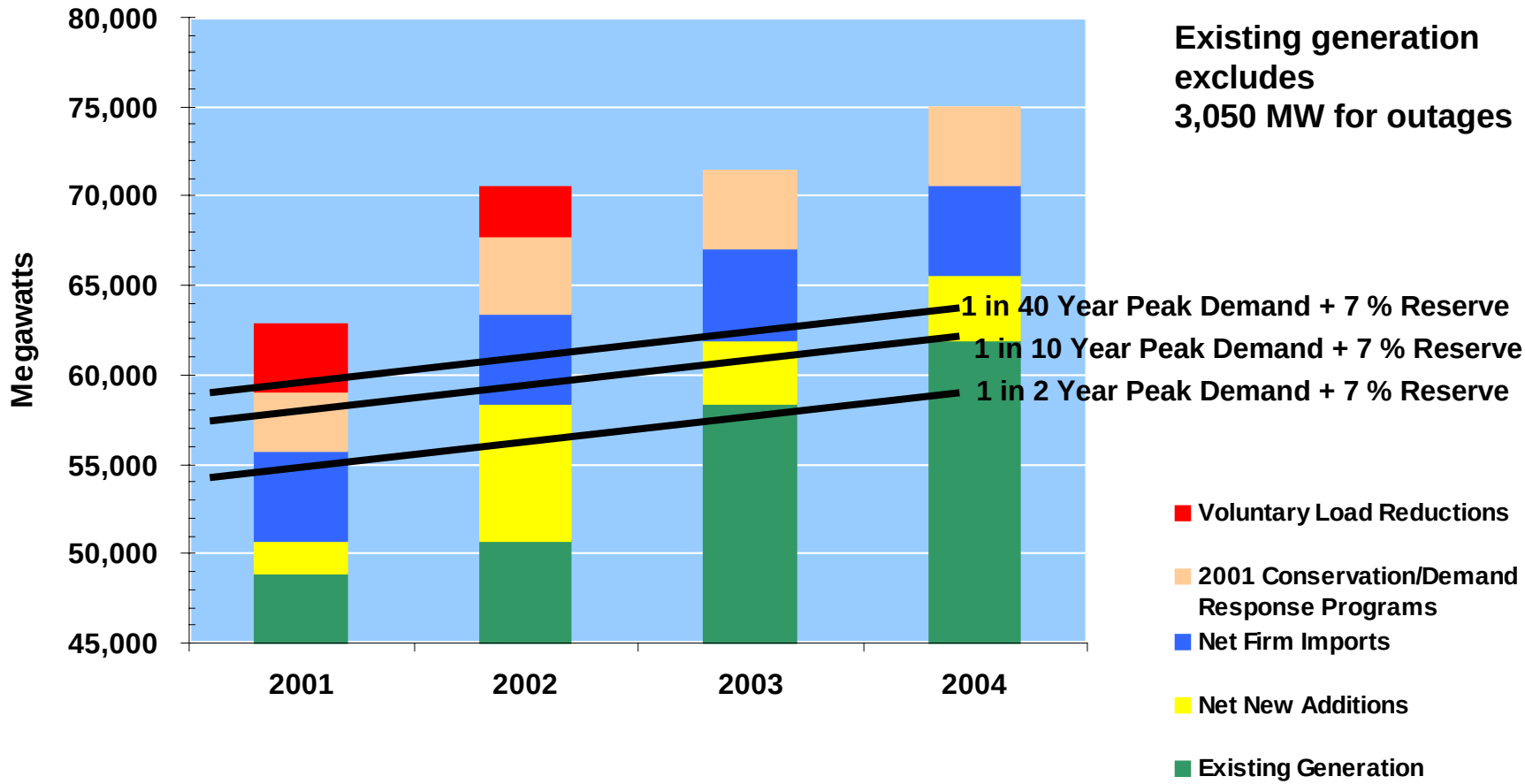
*Outage data for 2001 represents only through June

Electricity Congestion in CA

Increasing electricity demands in combination with little transmission infrastructure improvements have significantly congested T&D lines throughout the state

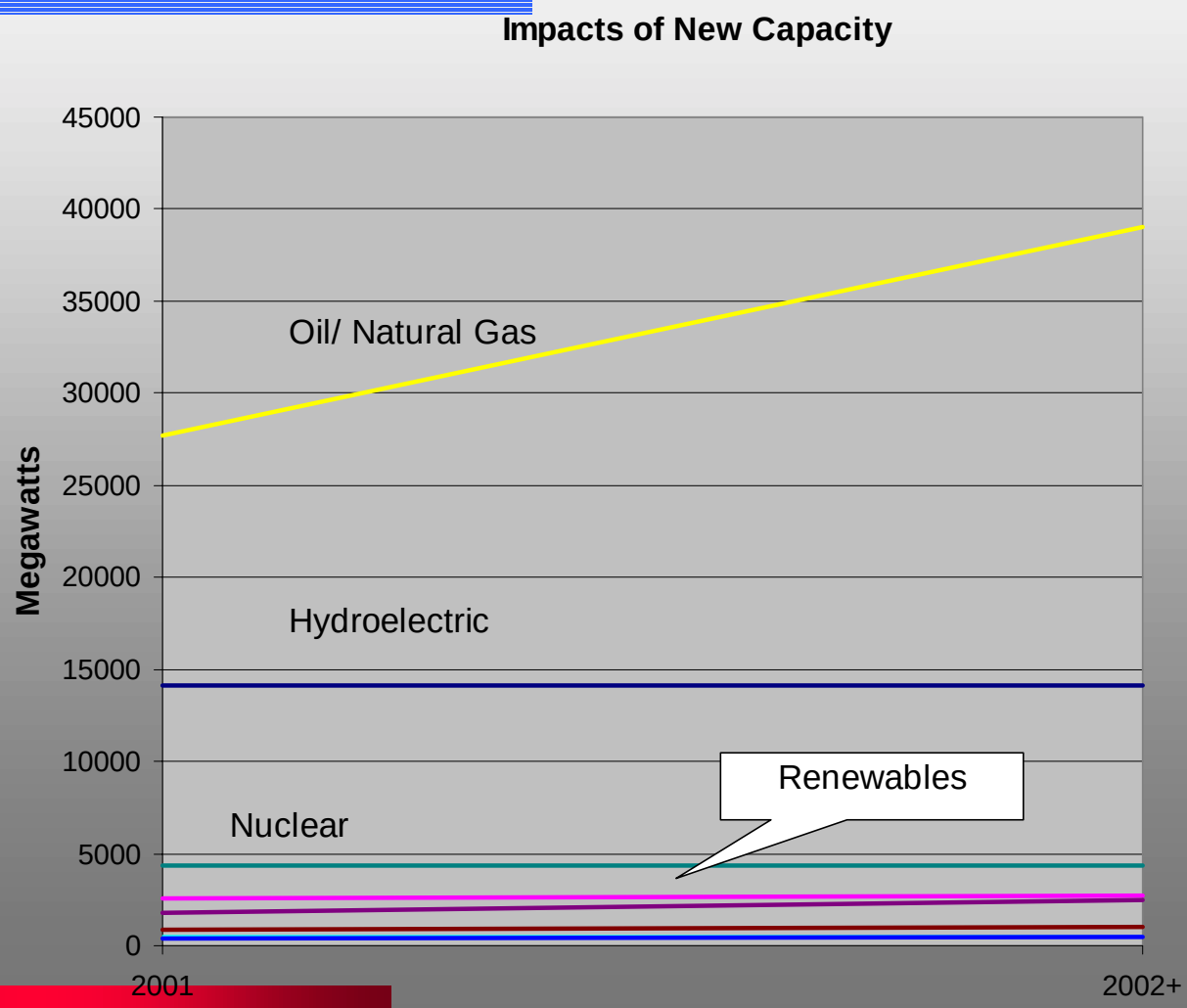


CA Future Supply and Demand



Impact of New Generation on Mix

Over 11,000 MW of new generating capacity has been approved in CA; almost 100% from natural gas. Over 60% of CA generation after 2003 will be natural gas based.



Does Response Address Problems?

- Fails to address T&D issues
  - Still have high congestion, reliability issues especially at distribution level
- Increases dependence on natural gas
  - Important as WSCC states also rely heavily on natural gas
- Still leaves rate payers with high costs and few options
  - Back where we started prior to deregulation?

What Other Options Exist?

- Use Mix of Generation Sizes
  - Use central station plants as backbone for system
  - Use distributed generation along congested lines and in areas where new T&D is problematic
- Employ Portfolio Approach to Resource Mix
  - Reduces dependence on single resource
- Benefits
  - More resilient system
  - Alleviates congestion
  - More affordable

Role of Distributed Generation

- **Capacity**
  - *In small groups, DG systems provide local capacity additions*
  - *As coordinated "mini-grids," DG systems provide dispatchable capacities and VAR support to designated areas throughout the grid*
  - *Potential for rapid siting and construction*
- **Reliability**
  - *Can help prevent outages and provide capacity and VAR support where centralized generation capacity is limited due to high congestion, insufficient transmission and distribution*
- **Prices**
  - *May help reduce prices by deferring T&D expansions; add critical peak generating capacity*

Renewables: Expanding the Mix

- Can renewables really help?
  - Existing renewable generation: ~ 7000 MW
  - Renewables potential: 79,000 MW
    - ✔ Biomass/WTE 5000 MW
    - ✔ Wind 7000 MW
    - ✔ Geothermal 4000 MW
    - ✔ Solar 60,000 MW
    - ✔ Small Hydro 3,000 MW ?
    - ✔ Ocean ??
- Questions on renewables become:
  - Cost
  - Performance

Why Renewable DG?

- **Renewables Widely Available in California**
  - *Resources close to areas experiencing grid problems*
- **Renewables Fit With DG Philosophy**
  - *Most renewable technologies already heading towards distributed generation configurations*
  - *Rapidly improving technology, opportunity to influence R&D priorities to address DG requirements*
- **Other Benefits**
  - *DG renewable can provide public benefits beyond grid support:*
    - ✔ *Environmental*
    - ✔ *Employment*
    - ✔ *Public Health*

Assessing Renewable DG Role

- **Assess Grid Impacts/Benefits**
  - Determine ability to provide capacity, VAR support, frequency control, congestion relief, etc.
  - Requires power flow modeling that includes renewable DG components
- **Assess Public Benefit Impacts**
  - Identify availability and magnitude of renewable resources
  - Quantify levels of benefits tied to use of renewables when used for distributed generation
- **Combined Grid/Public Benefits Assessment**
  - Identify impacts of renewable DG in areas facing electricity problems

Strategic Value Analysis Project

- Goal
  - Determining appropriate performance, cost and locations for renewable power systems to provide high strategic value to grid while simultaneously providing high public benefits
- Parallel contracts
  - Power Flow Modeling
    - ✔ McNeil Technologies, Davis Power Consulting, O'Conner Consulting
  - GIS Modeling
    - ✔ California Department of Forestry

Strategic Value Analysis Objectives

- Characterize generation and T&D problems confronting California's electricity system
- Identify electricity generation performance characteristics needed to address problems
- Identify locations where renewable resources can address "hot spots" and simultaneously provide high public benefits
- Identify R&D needed to develop renewables to meet required generation and cost performance characteristics

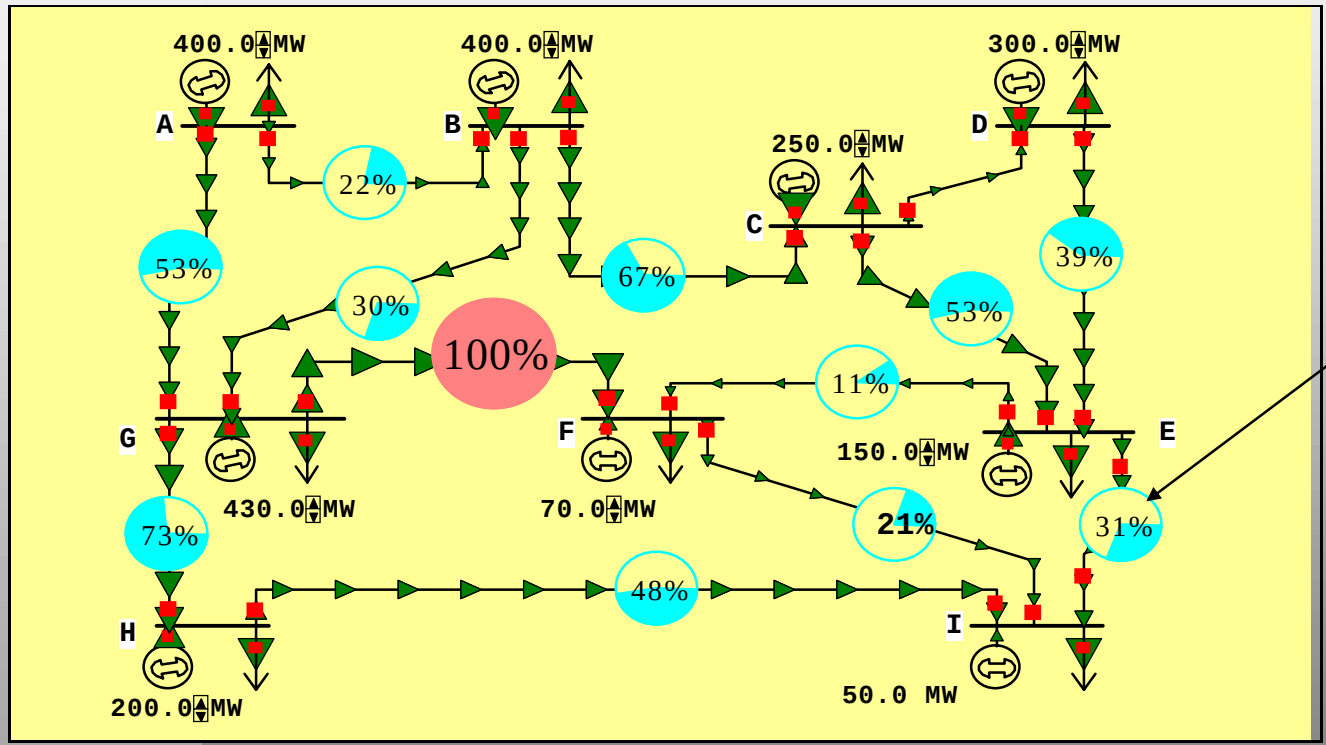
Overall Approach

- **Power Flow Models to Assess Grid Impacts**
  - Assess “hot spots” in California’s electricity system
  - Determine performance characteristics needed by localized electricity generators to help resolve “hot spots”
  - Iterative runs to identify suitable renewable DG penetration levels
- **GIS Model to Assess Combined Impacts**
  - Establish baseline resource and public interest layers in GIS
  - Plug in simulation results from power flows
  - Prioritize based on preliminary screening
  - Conduct case studies to “verify” results at local levels
  - Determine economics and technical performance goals

Power Flow Modeling: Steps

- **Develop Data Sets**
  - Collect generation, substation and T&D line information
  - Modify or correct data sets as needed
  - Fit power flow model with data sets to CA baseline
- **Run Models Under Various Scenarios**
  - Identify electricity system “Hot Spots” (down to 60 kV)
  - Identify generation or T&D characteristics that alleviate “Hot Spots”
  - Estimate renewable penetration levels
- **Provide Results to GIS for Case Studies**
  - Select representative “local” case studies
  - Run simulations at 12 kV line levels
  - Assess impacts

Power Flow Models Used to Simulate Renewable Impacts



Can identify congestion along lines

Determine generator characteristics needed to resolve identified problem, which then identifies renewable generator characteristics. Penetration analyses conducted to see how impacts from groups of renewables within mix

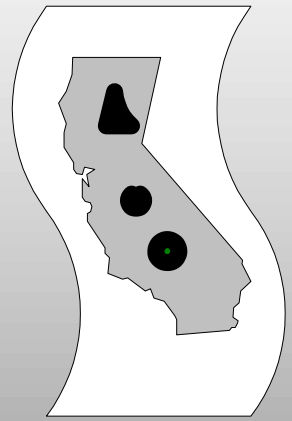
Figure from PowerWorld

GIS Analysis: Steps

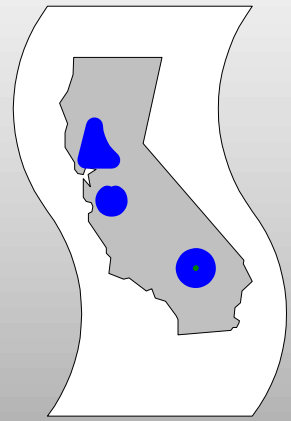
- **Develop GIS Data Sets**
  - Environmental (air quality, landfill capacities, etc.)
  - Demographics (e.g., unemployment)
  - Renewable resources (biomass, wind, insolation , etc.)
  - “Hot spots” from power flow modeling
- **Establish set points for sensitivity analyses**
- **Develop thematic layers and maps**
- **Combine thematic layers around various set points**
  - Generate combined result maps

Development of GIS Layers

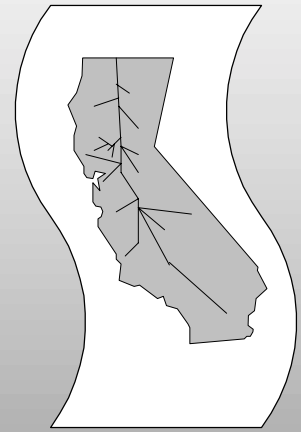
Baseline CA Layer



Layer for Ag Residues



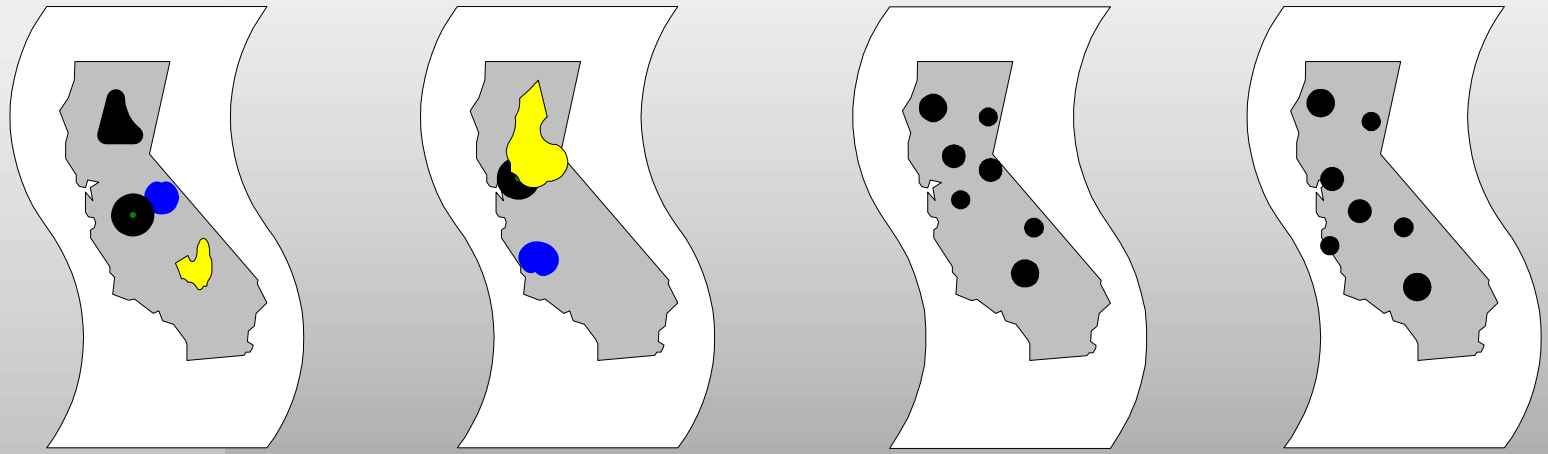
Layer for Wind Resource



Grid System Layer

Many thematic layers developed to depict electricity system conditions, environmental problems, renewable resources, etc.

GIS Sensitivity Results



Various Thematic Layers are Combined

Combinations Produce Sets of “Optimal” Locations

Sensitivity Analyses Then Used to Optimize Combined Sets

Combined Power Flow/GIS Analyses

- **Combined thematic layers analyzed for "optimal" results**
  - Addressing CA electricity needs
    - ✔ Generation Issues
    - ✔ T&D Issues
  - Developing high public benefits (non-electricity)
    - ✔ Environmental
    - ✔ Wildfire prevention
    - ✔ Rural economic development
    - ✔ etc.
- **Optimal results developed into overlay maps**
- **Analyses can be iterated for any given set of conditions**

Targeting Renewable Power R&D

- **Power flow and GIS results identify highest needs or opportunities, and associated best locations**
- **Technical analyses determine renewable power system performance characteristics and possible R&D targets**
- **Power flow simulations identify possible benefits at different penetration levels of renewable power systems in high need areas**
- **Local case studies test validity of approach and demonstrate ways to plan renewable DG projects that achieve objectives**
- **Generate listing of R&D targets for renewable power technologies (performance, cost, etc.)**

Products: GIS and Power Flows

- **GIS Related Products**
  - Data Sets
    - ✔ Environmental issues (air quality, landfill capacity, etc.)
    - ✔ Demographics (employment)
    - ✔ Wildfire risk
    - ✔ Renewable resources (biomass, wind, solar, etc.)
  - Thematic layers and maps of data sets
  - Combined thematic layers and maps
- **Power Flow Related Products**
  - Data Sets
  - Power Flow Models Specific to CA
  - Results of Modeling

Products: Analyses

- **Combined GIS/Power Flow Modeling**
  - Combined Data Sets
  - Combined Thematic Layers and Maps
  - Optimized Thematic Layers and Maps
- **Renewable Power R&D**
  - Performance Characteristics Needed to Address
    - ✔ CA Electricity Needs
    - ✔ High Public Benefits
  - Targets for Renewable Power Technologies
    - ✔ Generation Related Performance
    - ✔ Costs
    - ✔ Environmental

Next Steps: Proactive Interconnections

- Strategic Value Analysis is 1st Step
  - Only indicates where and generally what to develop
  - Renewable DG growth will dictate new ways to plan, deploy and control varied and dispersed generation systems
- Existing Interconnection Standards Limited
  - Primarily set to protect system and workers by isolating non-utility generation
  - Doesn’t recognize DG’s ability to enhance system resiliency and reliability
  - Need standards that enable safe, two-way flow of power from widely diverse and dispersed sources

California's Electricity Future?

Augmenting California's electricity system with renewable distributed generation facilities will pose control system challenges, but will create a system that provides greater benefits to rate payers, is more responsive to market conditions and offers significantly higher reliability at overall lower costs